

March 15, 2001

MEMORANDUM FOR: Clifton S. Middleton  
Project Director, Survey Section B

Gary W. Thompson  
Geodetic Liaison, North Carolina Geodetic  
Survey

Lewis A. Lapine  
Geodetic Liaison, South Carolina Geodetic  
Survey

FROM: Charles W. Challstrom  
Director, National Geodetic Survey

SUBJECT: INSTRUCTIONS: NORTH & SOUTH CAROLINA FBN/CBN,  
2001 (GPS-1554)  
Task Number: 8K6D2000

GENERAL:

The North Carolina Geodetic Survey (NCGS) and South Carolina Geodetic Survey (SCGS) will be observing stations of the Federal Base Network (FBN) and Cooperative Base Network (CBN) to complete the ellipsoidal and orthometric height components of the FBN and CBN as established by the NGS Strategic Plan. This survey will observe the 31 FBN stations in North Carolina, the 18 FBN stations in South Carolina, and selected CBN stations in North and South Carolina, and tie to FBN and CBN control in Georgia and Virginia.

NCGS and SCGS have performed the reconnaissance of both the FBN and CBN in their respective states.

NCGS and SCGS will observe the FBNs in their respective states and those CBNs which either are replacements for ones unsuitable for GPS or fill in "gaps" in their networks.

N/NGS21:DHendrickson:713-3194:amg:03-09-01  
A:\NSGPS

A bench mark at each of eight tide gauge sites in the two states is also included in the project and is to be surveyed to FBN specifications. Five sites are in North Carolina: Duck, Oregon Inlet Marina, Cape Hatteras Fishing Pier, Beaufort (Duke Marine Lab), and Wilmington. Three sites are in South Carolina: Springmaid Pier, Charleston, and Archer. NCGS and SCGS have performed the reconnaissance for the tide gauge sites and will also occupy them.

NCGS will provide 10 receivers for the project; SCGS will provide 6 receivers.

NGS will be responsible for the FBN border ties into Georgia and Virginia.

PURPOSE:

In order to meet America's accelerating positioning and navigation needs, the existing coordinate reference system must be continually enhanced to provide the accessibility and high accuracy required for use with GPS. The digital revolution in mapping, charting, and surveying requires a National Spatial Reference System (NSRS) consisting of, among other components, a network of monumented points having four-dimensional positions. The FBN fulfills the requirements for this component. NGS is charged with the Federal responsibility for establishment, observation, monitoring, and maintenance of the FBN. The FBN provides the critical network foundation for an accurate, consistent, reliable NSRS.

The NSRS, in turn, provides the common geographic framework for America's spatial data infrastructure. As such, the NSRS serves as the basis for mapping, charting, navigation, boundary determination, property delineation, infrastructure development, resource evaluation surveys, and scientific applications, including crustal motion monitoring, modeling of flooding, storm surge, pollution trajectories, and agricultural runoff. A modernized, accurate, consistent, reliable NSRS is of enormous benefit to state, county, tribal, local, and Federal authorities, as well as to the private sector.

The eight tide site surveys will provide GPS-derived ellipsoid heights, accurate to 2 cm, on tide site water level bench marks along the Atlantic coast.

SPECIFICATIONS:

Project requirements for the FBN observations are to ensure 2-centimeter local accuracy in the horizontal component, as well as 2-centimeter local accuracy for the ellipsoid heights.

Data from the CORS in the region are to be used in the processing. There are thirteen National CORS in the area to be selected from. Four are in North Carolina; three each are in Georgia and Virginia; two are in South Carolina; and one is in Tennessee.

There are also six community base stations in North Carolina and three in South Carolina.

The six North Carolina community base stations are located at Asheville, Conover, High Point, Raleigh, Washington, and Wilmington. The three community base stations in South Carolina are located at Columbia and two are at Greenville. The base station at Greenville which is operated by the South Carolina Geodetic Survey will not be operational until mid-year.

The four National CORS in North Carolina are: Duck (DUCK), Fort Macon (FMCl), High Point (HIPT), and Asheville (ASHV). The three National CORS in Georgia are: Savannah (SAV1), Evans (COGA), and Atlanta (ATL1). Driver (DRV1), Richmond (RIC1), and Blacksburg (BLKV) are the three National CORS in Virginia. Columbia (COLA) and Charleston (CHA1) are the National CORS in South Carolina. The National CORS in Tennessee is Hartsville (HTV1).

Positions for and data from the National CORS are available from the NGS web site. To get the positions for and data from the North Carolina and South Carolina community base stations, see LIAISON for each station.

General specifications for the project are as follows. At each FBN and CBN station, three sessions of 5 1/2 hours duration each shall be observed. The observing scheme shall be arranged so that for each station, the start time of one of the observing sessions is at least 4 hours different from the other two. The observing scheme shall be arranged to ensure that adjacent FBN and adjacent CBN stations are directly connected in at least one observing session, and at least half of all base lines are repeated.

In general, station occupation and observing procedures must be carried out according to appropriate sections of the "NGS Operations Handbook" and the current applicable receiver field manuals. Data formats and digital file definitions are given in "Input Formats and Specifications of the National Geodetic Survey Data Base," Volume I. Horizontal Control Data, Federal Geodetic Control Subcommittee, September 1994, revised and reprinted November, 1998. Success in meeting the accuracy standards will be based on repeatability of measurements and adjustment residuals.

General specifications for the project are given in "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques," Version 5.0: dated May 11, 1988, reprinted with corrections August 1, 1989. Specific project criteria and deviations from the general specifications are given in the following sections.

Project Network - A list (Table 1) and sketch of stations involved in this project will be provided.

Data Acquisition - Data collection must be accomplished as specified in the appropriate dual-frequency receiver field manuals in the compressed mode at a 15-second epoch collection interval. The GPS receivers must be dual-frequency and full-wavelength. Track satellites down to a 10-degree elevation angle.

Sessions will generally begin at two observing windows at least 4 hours apart. The observing windows will shift in weekly increments of 30 minutes instead of daily increments of 4 minutes. Vectors between the project stations shall be measured by single sessions consisting of continuously and simultaneously tracking for 5 1/2 hours.

Each FBN and CBN station must be occupied at least three times - twice at one observing window and once at the other. The survey shall include bench marks distributed throughout the project serving as ties. These bench marks shall also be FBN or CBN stations and are to be observed using the same specifications as the rest of the FBN and CBN stations.

Each FBN and CBN, if not a first- or second-order bench mark, must be tied to two different bench marks. This bench mark tie requirement can be satisfied in one or two sessions.

Adjacent FBN stations must be directly connected in at least one observing session, and at least one-half of all FBN base lines must be repeated.

CBN stations can be tied to adjacent FBN stations if the FBN station is closer than an adjacent CBN station. The repeated-base line requirement also applies to the CBN, although a base line consisting of a CBN station and a FBN station (instead of two CBN stations) can be used.

Record weather data just before, immediately after, and at the mid-point of each session. Meteorological data shall also be collected immediately after an obvious weather front passes during a session and immediately before it passes, if possible. Pressure and relative humidity measurements must be made near and at about the height of the GPS antenna phase center. Indicate in the log the location of the barometer and psychrometer.

Survey operations shall be conducted with due regard to the safety of personnel and equipment. Contact with the airport traffic control tower is mandatory during surveys at any controlled airports.

Vector Computations - Data management, quality review of collected data, and final vector processing for the FBN/CBN survey will be accomplished using PAGES. Vectors shall be computed in the International Earth Rotation Service Terrestrial Reference Frame (ITRF) system, using the most current epoch and precise IGS ephemerides. Use 30-second epoch intervals for data processing. Monument positions will be used for CORS when available, otherwise, antenna reference point (ARP) positions will be used. Survey Section B will be responsible for the data reductions and adjustments.

The data will be processed in 24-hour sessions (or slightly longer if the observation session crosses 0000 UTC) in order to utilize the 24-hour data sets collected at the CORS. The "fixed baseline" option in PAGES will be used to compute direct baselines between the CORS. The "fixed baseline" scheme will depend on the location and reliability of the CORS used in this project.

For stations where weather data are not available, or are suspect, predicted values will be computed and used based on the station's latitude, height above mean sea level, and time

and day of year. Use 15 degrees as the cutoff elevation angle in data processing. A cutoff angle of 10 degrees may be used when necessary to improve results.

The type of final solution, L1 versus ion-free, will depend on the length of the vectors. For vectors which are less than 10 km in length, the final reduction will consist of a L1 fixed solution. These vectors will be computed in a separate processing session from the longer vectors computed in an ion-free solution.

In general, vectors greater than 10 km in length are to be computed in an ion-free fixed, or partially-fixed, solution. In all cases, integer ambiguities will be fixed for each vector whenever possible.

The quality of collected data shall be determined from the plots generated from PAGES, by analysis of repeated vectors and/or comparison of station positions, and free adjustment residuals and/or loop misclosures. In addition, a constrained adjustment constraining all CORS will be performed.

NGS will perform all quality checks for conformance with NGS format standards such as executing software programs COMPGB, OBSCHK, and OBSDES. The final ITRF vectors will be assessed and transformed to the NAD 83 coordinate system using program ADJUST.

The data and results will be submitted to the Observation and Analysis Division. All B-files and G-files must be complete, including \*25\* and \*27\* records.

Station Descriptions - Station recovery notes must be submitted in computer-readable form using DDPROC software. Include the name, address, and, if public ownership, the telephone number of the responsible party. Do not include the telephone numbers of private property owners. NCGS and SCGS will be responsible for the descriptions.

Special Requirements - Antenna set-up is critical to the success of this project. Fixed-height tripods are preferred for all receivers. The plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when plumbing is performed. They must be shaded for 3 minutes before checking

and/or re-plumbing. Also, the perpendicularity of the poles must be checked at the beginning of the project and any other time there is suspicion of a problem.

When a fixed-height tripod is not used, the height of the antenna must be carefully measured to prevent station set-up blunders from occurring. Tribrachs used for these set-ups must be checked and adjusted when necessary. Totally independent measurements of the antenna height above the mark in both metric and English units must be made before and after each session. Someone other than the observer must check the measurement computations by carefully comparing measurements and then entering his/her initials on the log.

Some GPS antennas have detachable ground planes and radomes. In order to help identify what exactly was used at a particular site, it would be useful to have a snapshot of the setup. All observers should take a photograph of the setup, if possible, with a close-up of the antenna as viewed from the side.

In addition, digital photographs of each survey mark are required. See "Requirements for Digital Photographs of Survey Marks & CORS Antennas," Version 5, for specific information.

Also, a rubbing of the stamping of the mark must be made at each visit to a station. If it is impossible to make a rubbing of the mark, a plan sketch of the mark must be substituted, accurately recording all markings.

Also, for each station visited, a visibility obstruction diagram must be prepared and the TO-REACH description carefully checked for errors or omissions.

Lastly, the following must be recorded at each occupation of a station:

- (1) receiver manufacturer,
- (2) antenna manufacturer,
- (3) receiver model number (part number),
- (4) antenna model number (part number),
- (5) the complete serial number of the receiver, and
- (6) the complete serial number of the antenna.

Success of this project requires that the highest quality GPS data be collected. Therefore, during each station occupation, the operators shall carefully monitor the operation of the receivers. Any irregularities in the data due to equipment malfunction, DOD adjustment of the satellite orbit, obstructions, etc., must be reported to the Project Development Branch, N/NGS21, as soon as possible and noted on the observing log. If the quality of observations for an observing session is questionable, notify the Project Development Branch immediately.

GPS DATA:

Using TRIMBLE mission planning software or program SATMAP, consult visibility tables and plots of the current satellite constellation to select the best observing windows.

A project report and data listed in Annex L of "Input Formats and Specifications of the NGS Data Base" and in the attached addendum for the adjustment portion of the project must be transmitted. Any data considered suspect as to quality in achieving accuracy standards should be sent via FedEx immediately for office review. Backup of transmitted data must be held until notified by the Project Development Branch, N/NGS21.

The data set collected during the project shall be named "ncsc051d.824". All records in connection with this project shall be titled "NORTH & SOUTH CAROLINA FBN/CBN, 2001". The project number (accession number) is GPS-1554.

LIAISON:

Liaison must be maintained with designated offices at the National Geodetic Survey headquarters located at:

1315 East-West Highway  
Silver Spring, Maryland 20910-3282

Questions and problems concerning survey field operations should be directed to:

William T. McLemore, Jr.  
Chief, Field Operations Branch  
Observation and Analysis Division  
N/NGS41, SSMC III, Station 8564

Telephone: 301-713-3215, ext. 117  
Fax: 301-713-4327  
e-Mail: Bill.Mclemore@noaa.gov

Questions and problems concerning adjustment processing should be directed to:

Maralyn L. Vorhauer  
Observation and Analysis Division  
N/NGS4, SSMC III, Station 8562  
Telephone: 301-713-3176, ext. 104  
Fax: 301-713-4327  
e-Mail: Maralyn.Vorhauer@noaa.gov

Questions and problems concerning vector processing should be directed to:

Juliana Blackwell  
Field Operations Branch  
Observation and Analysis Division  
N/NGS41, SSMC III, Station 8458  
Telephone: 301-713-3215, ext. 108  
Fax: 301-713-4327  
e-Mail: Juliana.Blackwell@noaa.gov

Questions and problems concerning using CORS data in processing should be directed to:

Neil Weston  
Geosciences Research Division  
N/NGS6, SSMC III, Station 9830  
Telephone: 301-713-2847, ext. 202  
Fax: 301-713-4475  
e-Mail: Neil.D.Weston@noaa.gov

Questions and problems which could affect the technical adequacy of the project should be directed to:

Stephen J. Frakes (Douglas R. Hendrickson)  
Chief, Project Development Branch  
Spatial Reference System Division  
N/NGS21, SSMC III, Station 8853  
Telephone: 301-713-3194, ext. 111 (ext. 127)  
Fax: 301-713-4316  
e-Mail: Steve.Frakes@noaa.gov  
(Doug.Hendrickson@noaa.gov)

The contact with the NCGS is:

Gary W. Thompson  
Chief, North Carolina Geodetic Survey  
Office of State Planning  
Elks Building  
121 West Jones Street  
Raleigh, North Carolina 27603-1334  
Telephone: 919-733-3836  
Fax: 919-733-4407  
e-Mail: gary.thompson@ncmail.net

The contact with the SCGS is:

Lewis A. Lapine  
South Carolina Geodetic Survey  
5 Geology Road  
Columbia, South Carolina 29212  
Telephone: 803-896-7700  
e-Mail: llapine@scgs.sc.us

The contact for ties into Virginia is:

Mr. Mike Zmuda  
Virginia Department of Transportation  
1401 East Broad Street, Room 914  
Richmond, Virginia 23219  
Telephone: 804-786-2565  
e-Mail: zmuda\_mw@vdot.state.va.us

The contacts for ties into Georgia are:

Mr. Lamar Stone  
Georgia Department of Transportation  
Office of Location  
3993 Aviation Circle  
Atlanta, Georgia 30336-1593  
Telephone: 404-699-4470  
e-Mail: lamar.stone@dot.state.ga.us

Mr. M. Greg Johnson  
Georgia Power Company  
Land Department, Bin 20020  
333 Piedmont Avenue  
Atlanta, Georgia 30308  
Telephone: 404-526-4902  
e-Mail: greg.johnson@gpc.com

Mr. Ski Bashinski, Executive Director  
Surveying and Mapping Society of Georgia  
P.O. Box 360329  
Decatur, Georgia 30036-0329  
Telephone: 404-288-8473

Mr. Ray Argo, Director  
Carl Vinson Institute of Government  
Information Technology Outreach Services  
1180 East Broad Street  
Chicopee Complex, Room 2076  
Athens, Georgia 30602

Mr. Jack Martin  
Georgia Department of Community Affairs  
60 Executive Parkway South NE  
Atlanta, Georgia 30329-2231  
Telephone: 404-679-3144

The contact for the Asheville, Raleigh, Washington, and  
Wilmington, North Carolina, community base stations is:

Mr. John Gardner  
North Carolina Geodetic Survey  
512 N. Salisbury Street  
Raleigh, North Carolina 27611  
Telephone: 919-733-3836  
Fax: 919-733-4407  
Web: <http://www.ncgs.state.nc.us/ncgsbase.html>  
(Asheville) FTP: <ftp://ftp.ncgs.state.nc.us/gps/asheville>  
(Asheville) BBS: 704-251-6072  
  
(Raleigh) FTP: <ftp://ftp.ncgs.state.nc.us/gps/raleigh>  
(Raleigh) BBS: 919-715-0557

(Washington) FTP: <ftp://ftp.ncgs.state.nc.us/gps/washington>  
(Washington) BBS: 919-975-6187

(Wilmington) FTP: <ftp://ftp.ncgs.state.nc.us/gps/wilmington>  
(Wilmington) BBS: 919-975-6187

The contact for the Conover, North Carolina, community base station is:

Mr. Terry Brown  
City of Conover  
Conover, North Carolina 28613  
Telephone: 828-464-4808  
Fax: 828-464-5299  
Web: <http://www.ncgs.state.nc.us/ncgsbase.html>  
FTP: <ftp://ftp.ncgs.state.nc.us/gps/conover>

The contact for the High Point, North Carolina, community base station is:

Ms. Karen Zera  
City of High Point  
Telephone: 336-883-8527  
e-Mail: [gps-webmaster@ci.high-point.nc.us](mailto:gps-webmaster@ci.high-point.nc.us)  
Web: <http://commnt2.ci.high-point.nc.us/gpshome.html>  
FTP: <http://commnt2.ci.high-point.nc.us/ursdata/ssf/>

The contact for the Columbia and one of the Greenville, South Carolina, community base stations is:

Mr. Matt Wellslager  
South Carolina Geodetic Survey  
5 Geology Road  
Columbia, South Carolina 29212  
Telephone: 803-896-7704  
Fax: 803-896-7695  
e-Mail: [mattw@scgs.state.sc.us](mailto:mattw@scgs.state.sc.us)  
(Columbia) Web: <http://167.7.12.143/UrsData/dat/>  
(Columbia) FTP: <ftp://167.7.12.143/UrsData/dat/>  
  
(Greenville) BBS: 803-467-5724

The contact for the other Greenville, South Carolina, community base station is:

Mr. Jeff McLeroy  
City of Greenville  
206 S. Main Street  
Greenville, South Carolina 29611  
Telephone: 864-467-4417  
Fax: 864-467-5754  
e-Mail: mcleroj@greatergreenville.com  
Web: <http://base.greatergreenville.com>  
BBS: 864-467-5724

For tide gauge site information, contact:

Mr. Tom Landon  
Center for Operational Oceanographic  
Products and Services  
Requirements and Development Division  
N/OPS1, SSMC IV, Station 6409  
1305 East-West Highway  
Silver Spring, Maryland 20910  
Telephone: 301-713-2897, ext. 191  
Fax: 301-713-4435  
e-Mail: Thomas.Landon@noaa.gov

Names and telephone numbers of local contacts are given in the station description material.

Expenses for this project will be charged to task number 8K6D2000.

cc: N/NGS - D. Zilkoski\*  
N/NGS - S. Misenheimer\*  
N/NGS1 - G. Mitchell  
N/NGS11 - S. Cofer  
N/NGS21 - S. Frakes  
N/NGS21 - R. Anderson  
N/NGS21 - D. Hendrickson\*  
N/NGS22 - T. Soler  
N/NGS3 - J. Bailey  
N/NGS4 - E. Wade  
N/NGS4 - M. Vorhauer  
N/NGS4 - D. Hoar  
N/NGS41 - W. McLemore  
N/NGS41 - J. Blackwell  
N/NGS5 - R. Snay  
N/NGS6 - N. Weston  
N/OPS1 - T. Landon  
FGCS Members\*  
Dick Woods, South Carolina Geodetic Survey  
Dannie Novak, South Carolina Geodetic Survey  
Charles Geoghegan, South Carolina Geodetic Survey  
Mike Zmuda, Virginia Department of Transportation  
Lamar Stone, Georgia Department of Transportation  
M. Greg Johnson, Georgia Power Company  
Ski Bashinski, Surveying and Mapping Society of Georgia  
Ray Argo, Carl Vinson Institute of Government  
Jack Martin, Georgia Department of Community Affairs  
John Gardner, North Carolina Geodetic Survey  
Terry Brown, City of Conover  
Karen Zera, City of High Point  
Matt Wellslager, South Carolina Geodetic Survey  
Jeff McLeroy, City of Greenville

\* first page only

DATA TO BE SENT TO HEADQUARTERS RELATING TO  
THE ADJUSTMENT PORTION OF  
FBN/CBN PROJECTS

Free adjustment in NAD 83 (UNIX run).

Plots of the free adjustment created by running "plotres\_prompt.bsh" on a UNIX server. Plots require a printer that supports postscript. The output file (long.out) contains a list of residuals which may be sorted using the following commands:

```
vi long.out
:1,$ !sort +0.47 (sorts horizontal residuals)
:1,$ !sort +0.71 (sorts vertical residuals)
```

(OPTIONAL) Constrained horizontal adjustment holding NGS CORS positions and ellipsoid heights.

Final combined Blue Book file (ASCII required) with \*86\* records (GEOID99).

Final description file (ASCII required.)

Final G-file (ASCII required.)

OBSCHK output.\* \*\*

CHKDDESC output.\*

OBSDES output.\*

\* Any errors or warning messages must be explained.  
\*\* Errors relating to incomplete \*86\* records are acceptable.